Caltrans BMP Retrofit Pilot Program

Scott Taylor, P.E.

RBF Consulting

&

Michael Barrett, Ph.D., P.E.

Center for Research in Water Resources

University of Texas at Austin

Acknowledgements

- Caltrans BMP Retrofit Pilot Program
  - Project Management – UC Davis
  - BMP Implementation – RBF Consulting, Montgomery Watson, Brown and Caldwell
  - BMP Operation and Monitoring – LawCrandall, and Kinnetic Laboratories

Study Objectives and Scope

- Objectives
  - Evaluation of constituent removal
  - Observe technical feasibility
  - Construction and O&M costs
- Scope
  - Siting
  - Design
  - Construction
  - Observation/monitoring

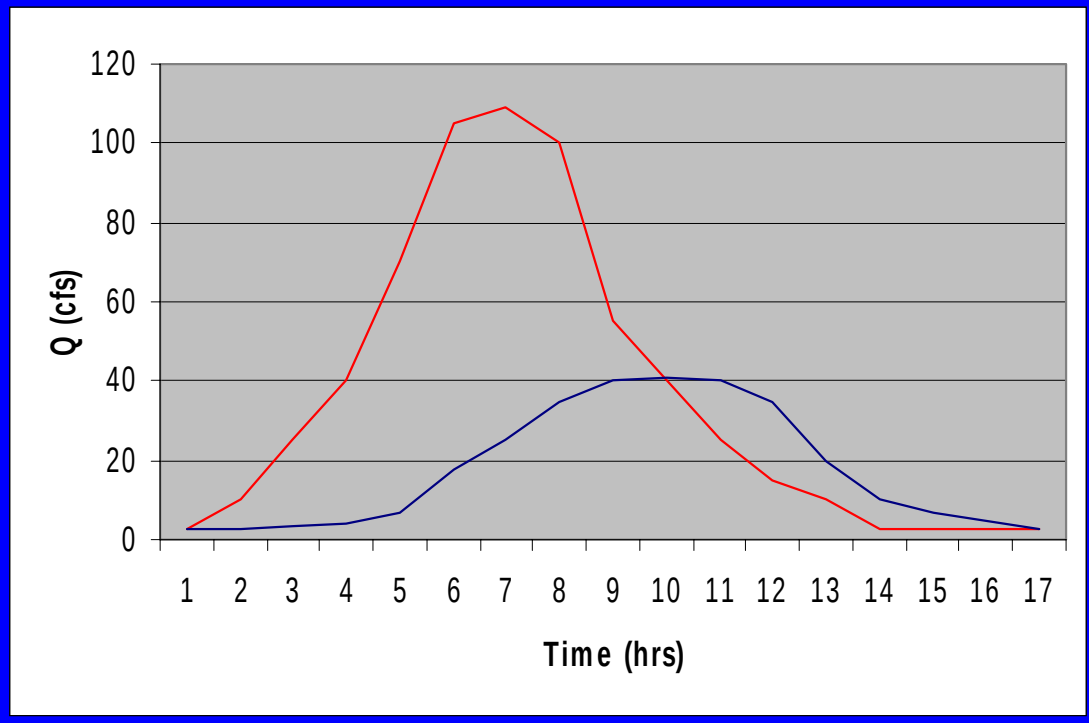
Study BMPs

- The study evaluated 37 BMPs at 33 sites with 9 types of technology:
  - Extended detention basin
  - Drain inlet inserts
  - Infiltration
  - Oil/Water separator
  - Media filter
  - MCTT
  - Biofilter
  - Wet Basin
  - CDS

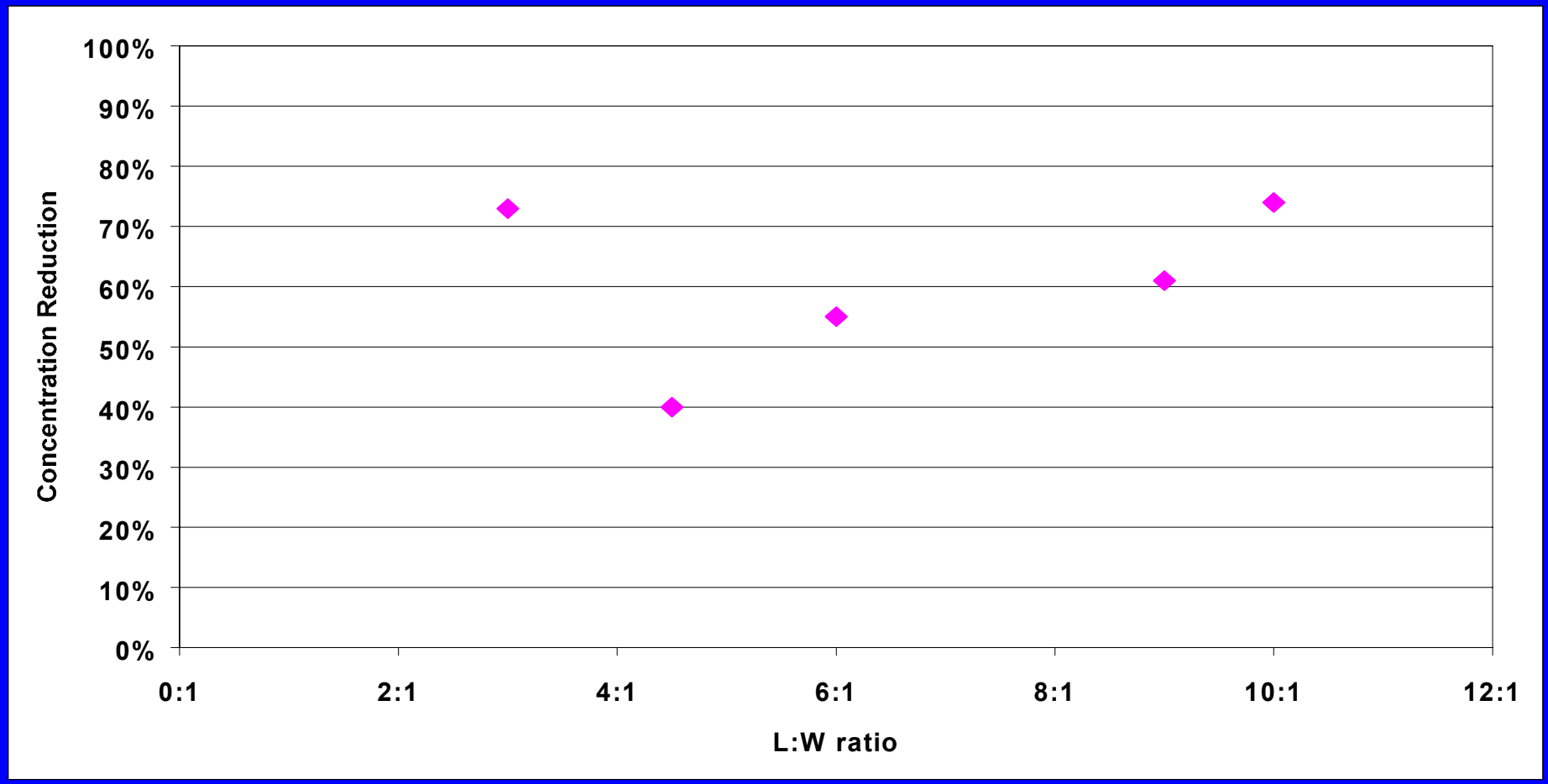
Extended Detention Basin

Lessons Learned - EDBs

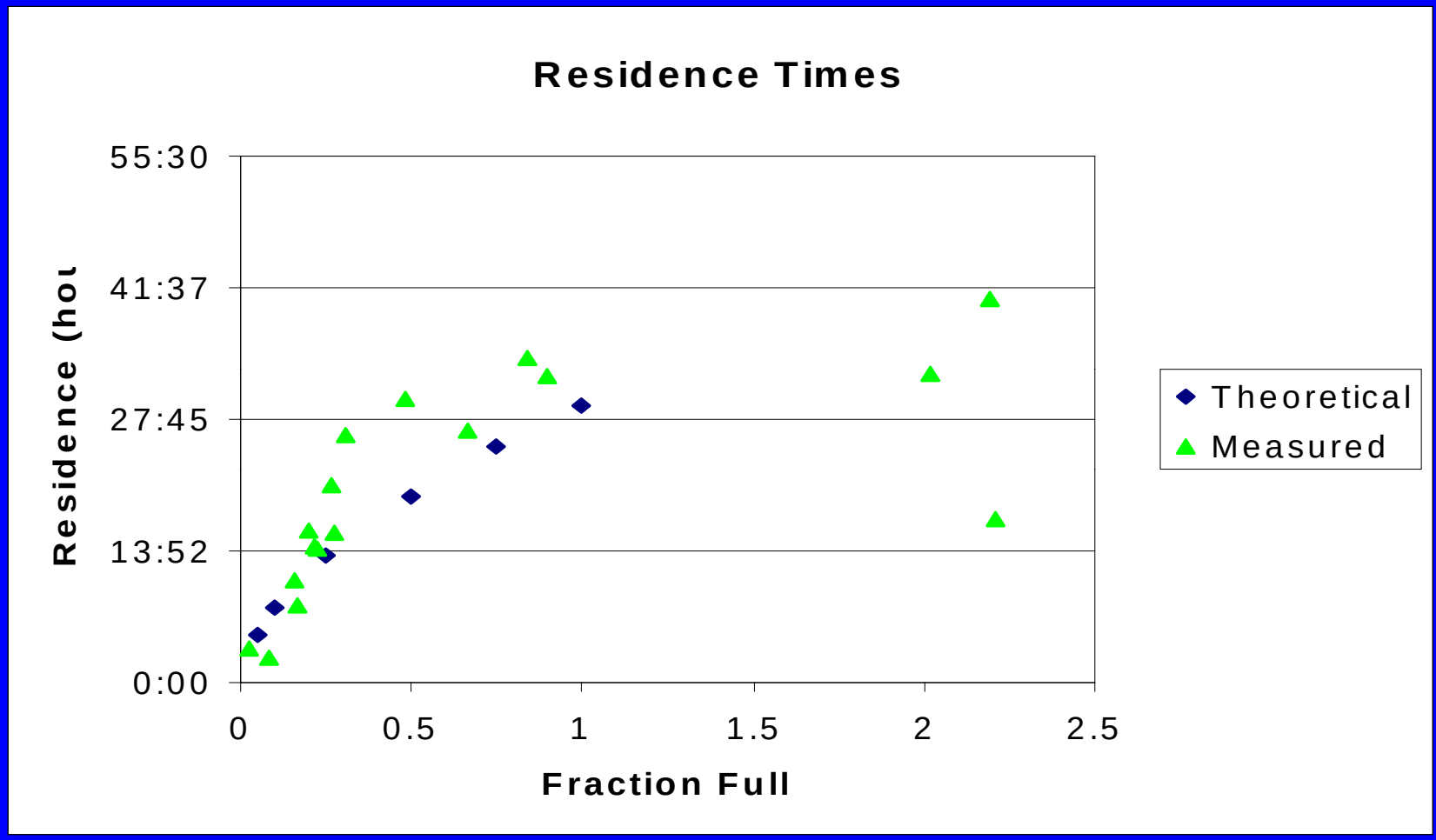
- Length to width ratio
- Relationship of drain time to detention time



L:W Ratio v. TSS Removal



Drain Time and Residence Time



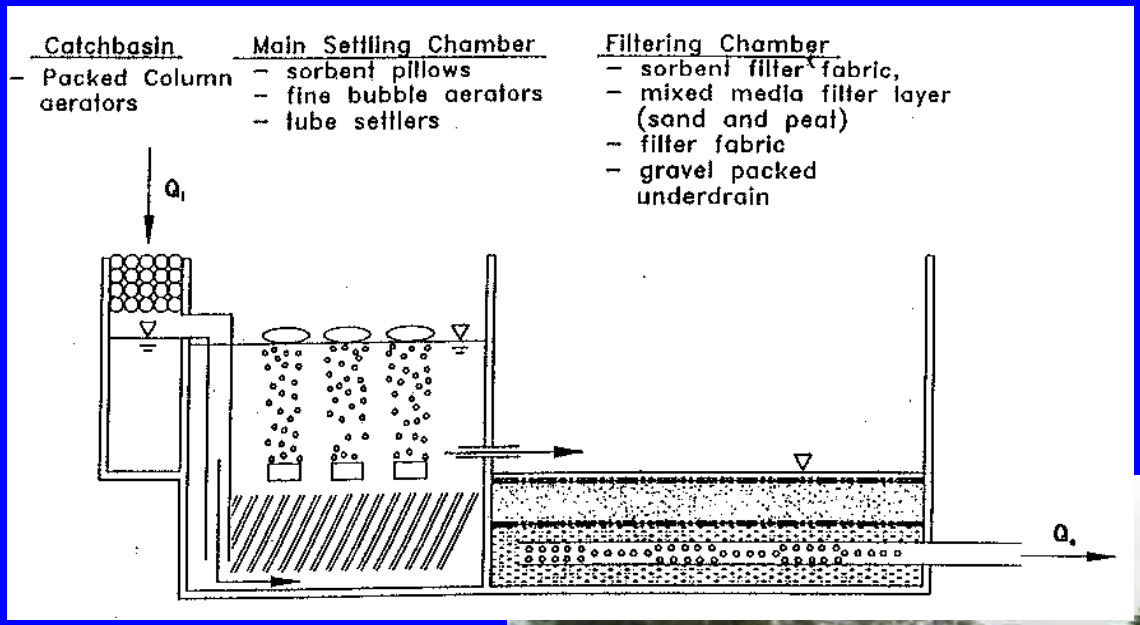
Infiltration

Lessons Learned - Infiltration

- Previous studies note general failure rate of infiltration devices about 50% within the first 5 years
- Consistent with Caltrans pilot experience
- Siting criteria significantly revised
- Potential impacts to ground water quality remain unknown

Sand Media Filter

Multi-Chambered Treatment Train



Lessons Learned - Media Filter/MCTT

- Flow spreading device unnecessary
- Maintenance access must be improved
- MCTT performance similar to SF
- Future research to investigate capital cost reduction:
  - Earth construction
  - Combined sedimentation/filter
  - Capital cost reductions of about 40%

Biofilters

Lessons Learned - Biofilters

- Selection of vegetation
  - Rapid growth
  - Low maintenance
  - Amount of sunlight
- Design criteria
  - Currently very poor guidance
  - Based on ‘residence’ time

Wetbasin

Lessons Learned - Wetbasin

- Little guidance on permanent pond volume
- Guidance on draw down time varies
- Vegetation maintenance is significant
- Vector issues are significant
- L:W ratio and depth are significant design factors
- Perennial source of water necessary?

General Lessons Learned

- Retrofit more complex/costly than new construction
- Room to improve BMP design
- Significant External Factors:
  - Vectors
  - Endangered species
  - Regulatory agencies
  - Aesthetics

Monitoring Summary

- Paired flow weighted samples collected from 26 facilities
- Grab or single samples collected from additional 11 sites
- Over 13,400 chemical analyses performed on paired samples

Summary of Constituent Removal

	TSS	Nitrate	TKN	P
Wet Basin	93%	61%	27%	5%
MCTT	75%	-63%	18%	18%
Austin MF	90%	-71%	41%	39%
Delaware MF	81%	-55%	44%	44%
Bio Strip	83%	36%	47%	7%
Extended Det.	76%	35%	37%	53%
Bio Swale	77%	60%	69%	8%

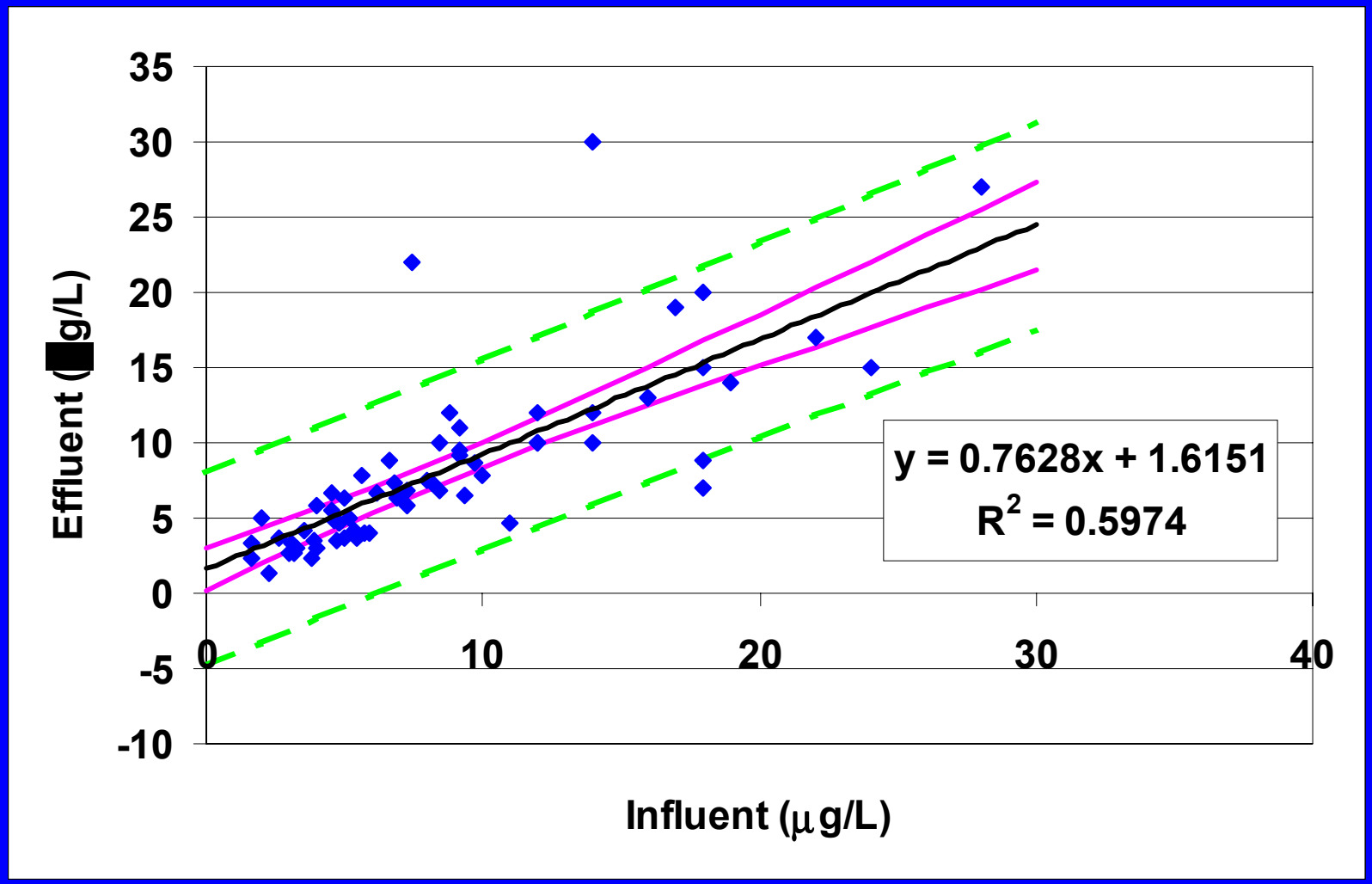
Strips, Swales, EDBs are Load Reduction

Methodology

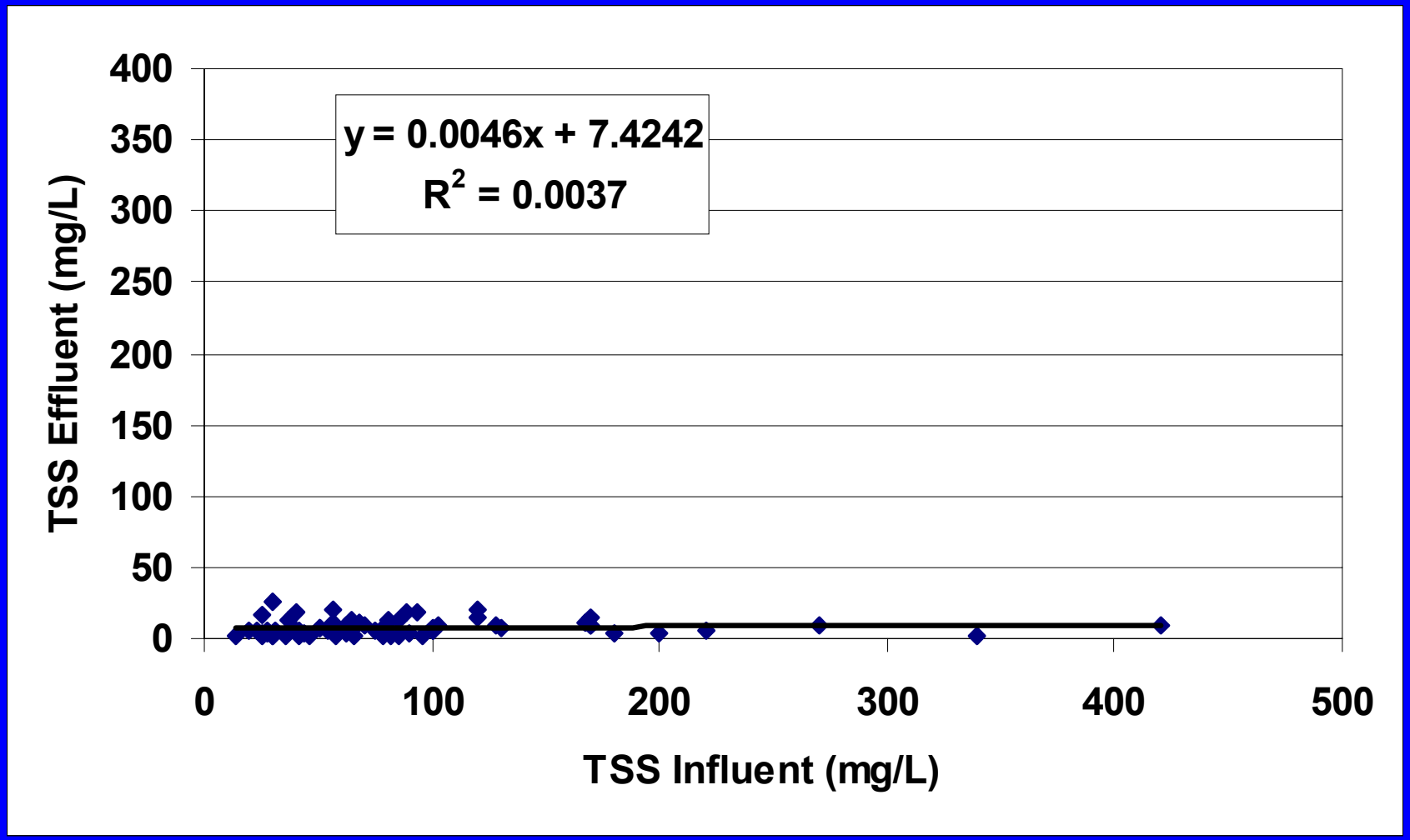
- Influent plotted against effluent EMC to determine relationship
- Confidence interval calculated for regression equation
- Water quality design storm estimated and used to compare BMPs

Typical Regression Relationship

Sand Filters - Dissolved Cu



Sand Filter - TSS



General Relationships

- Sand filters – effluent concentrations of particle associated constituents independent of influent C
- Wet basins – all effluent concentrations independent of influent C
- Other BMPs – essentially all effluent C linearly related to influent C

Design Storm Concentrations

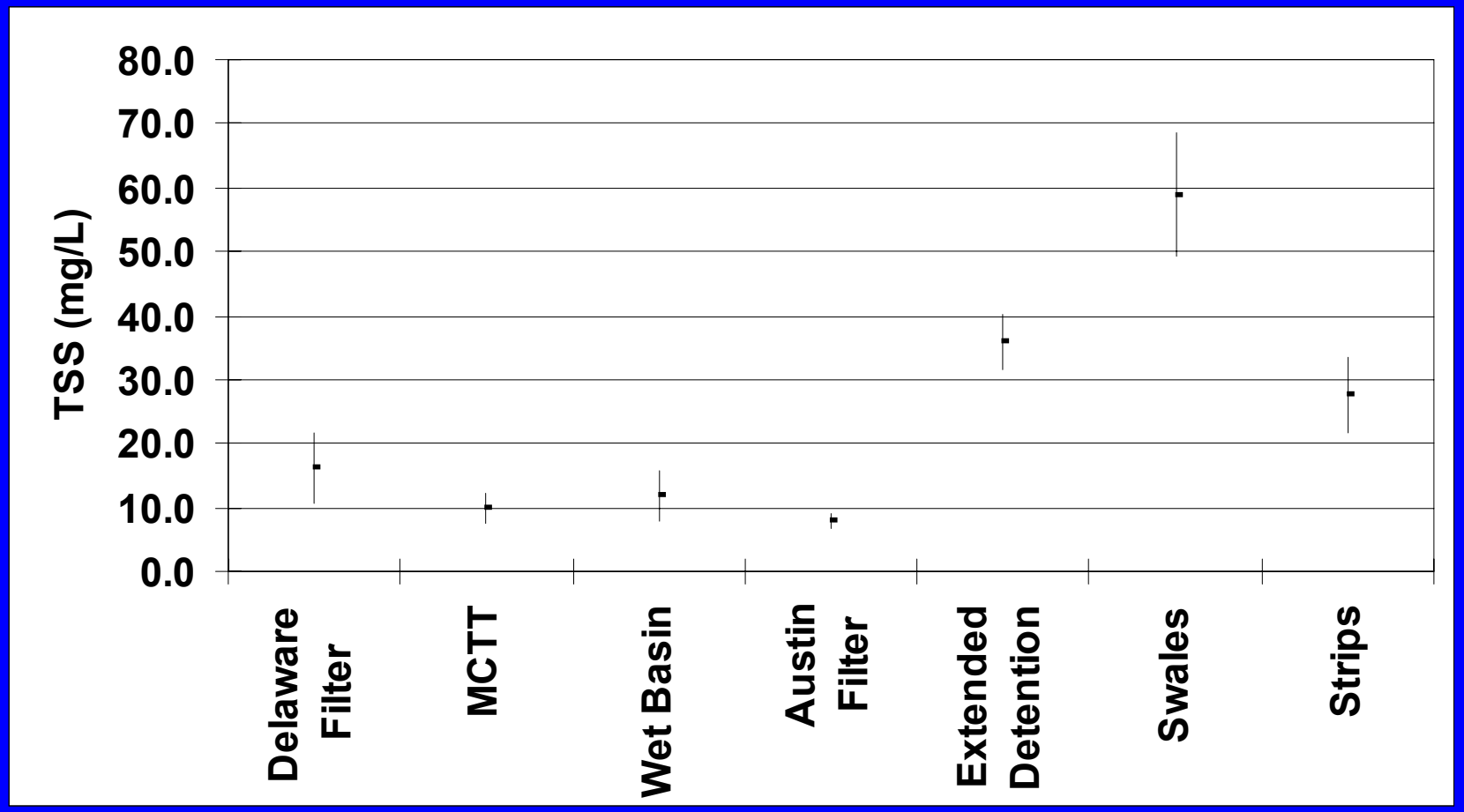
Constituent	Concentration[a]
TSS	114
Nitrate (as N)	0.97
Total Kjeldahl Nitrogen	2.36
Ortho-phosphorus	0.12
Particulate Phosphorus	0.26
Dissolved Copper	18
Dissolved Zinc	122
Dissolved Lead	8

[a] Concentration in mg/L except metals which are µg/L.

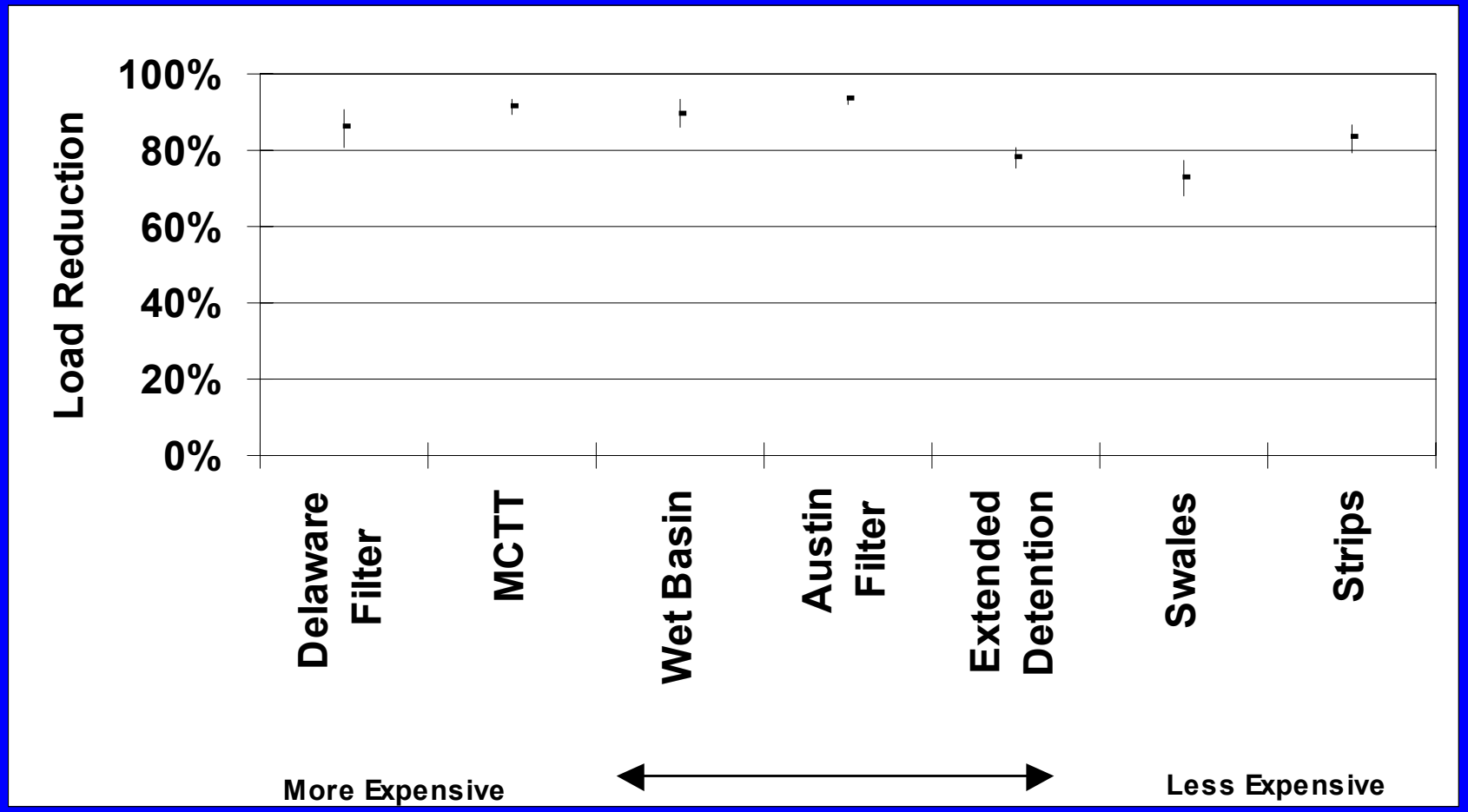
BMP Relative Construction Cost

BMP Type	Cost/m^3 of the Design Storm
Delaware Sand Filter	$3,500
MCTT	$2,850
Wet Basin	$2,640
Austin Filter	$2,000
StormFilter	$1,575
Lined Extended Detention	$350
Unlined EDB	$875
Swales	$700
Infiltration Basins	$640
Strips	NA
Drain Inlet Inserts	$37

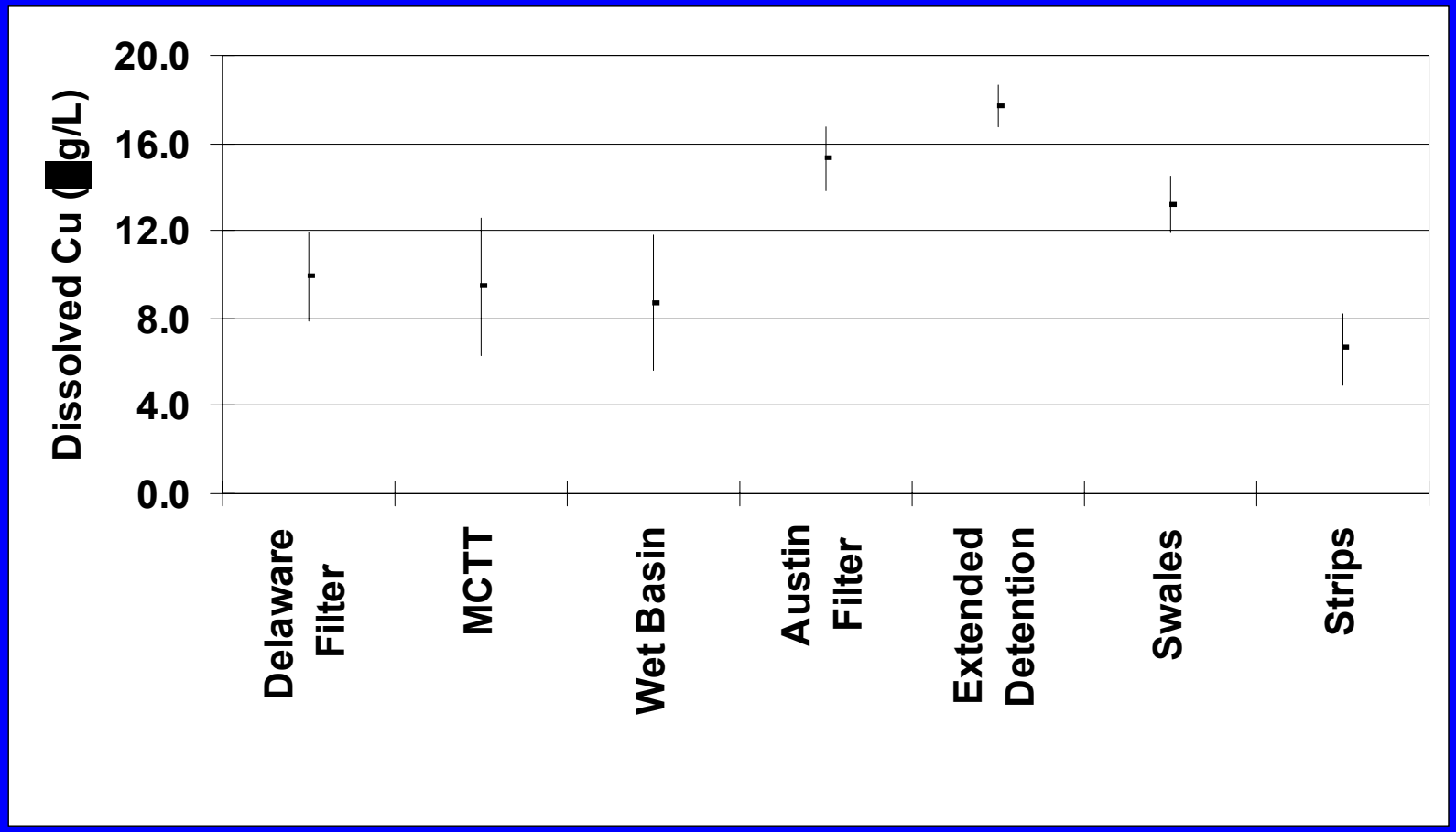
TSS Effluent (114 mg/L in)



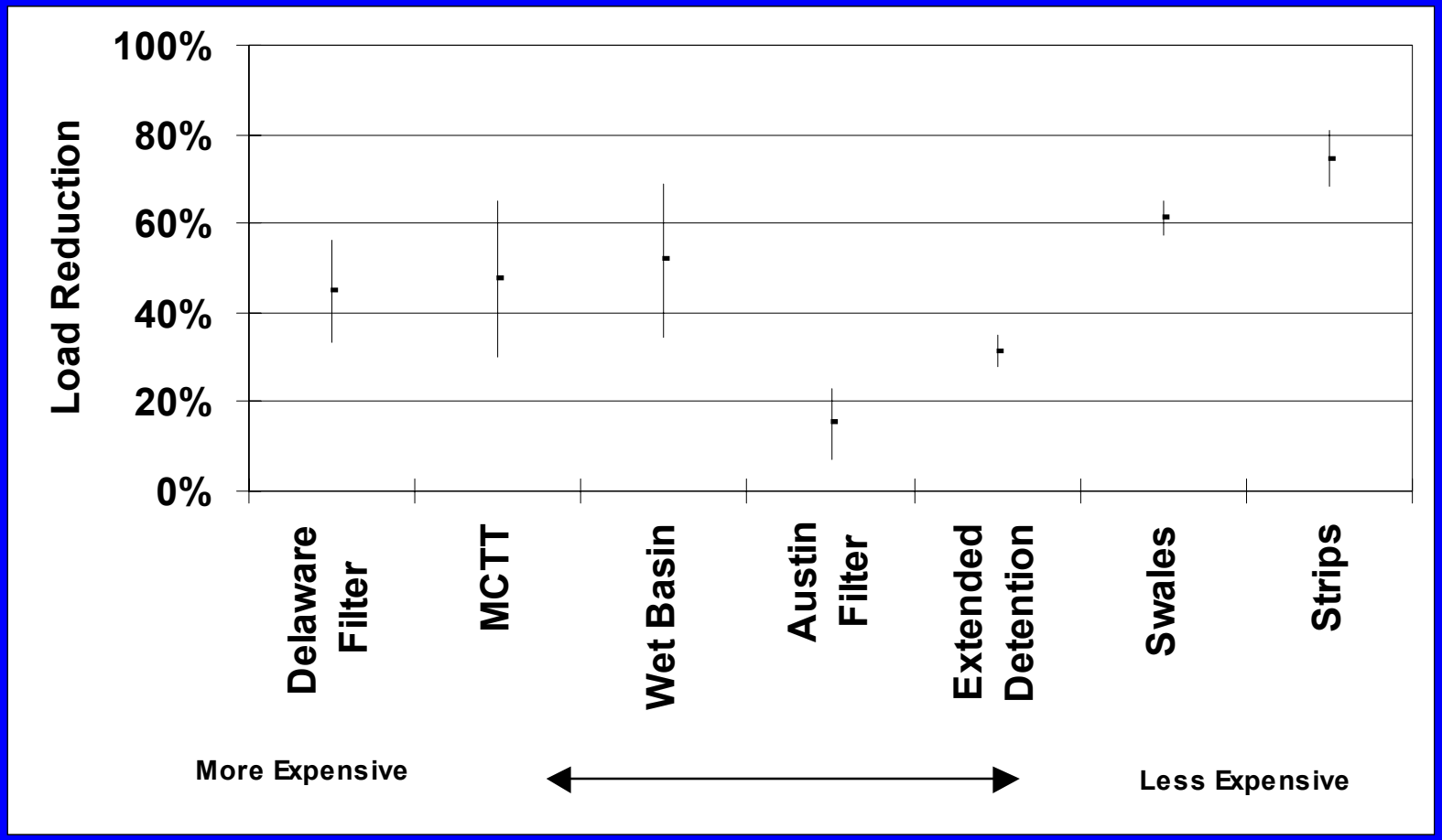
TSS Load Reduction



Dissolved Cu Effluent (18 μg/L)



Dissolved Cu Load Reduction



Sand Filters

- No significant change in constituent removal as filters clogged
- Very consistent effluent quality unrelated to influent concentration
- Significant performance differences among the sites for TSS

Biofilters (Swales and Strips)

- Exported phosphorus for entire study
- Filter strips tended to have more concentration reduction
- Infiltration Effects
  - 30% load reduction for strips
  - 50% load reduction for swales

Extended Detention
TSS reduction

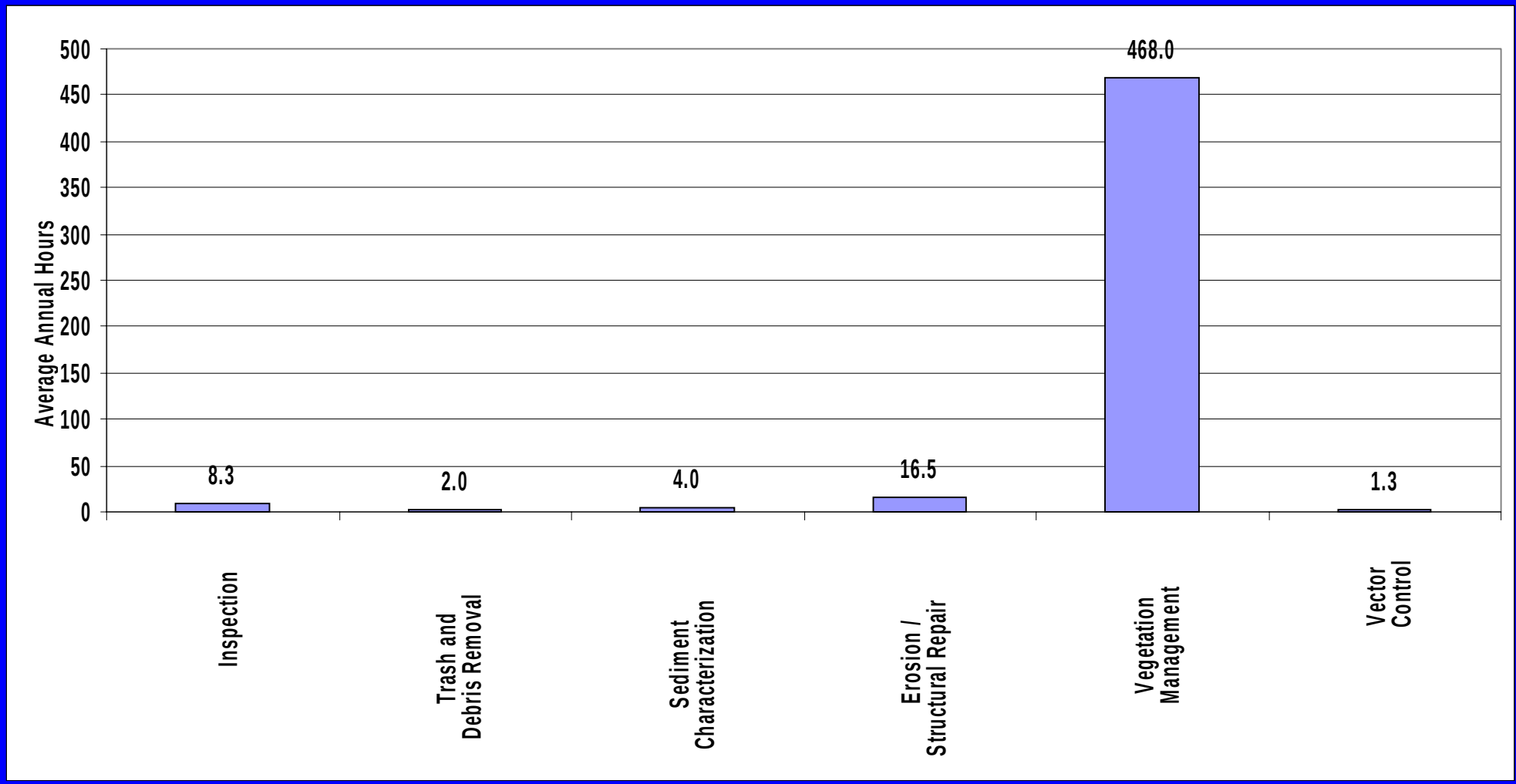
- Best concentration reduction at two unlined basins in San Diego (74%)
- Lowest concentration reduction at the concrete lined basin (40%)
- Best load reduction at inland site in LA (89%)
- Infiltration Effects
  - 30% of load reduction
  - Range 60% to 8%

Overview of Operation and Maintenance Labor Hours/Cost

Average Annual Maintenance (hrs)

Wet Basin	500
MCTT	220
Strips	180
Swales	116
Inf. Basin	89
Extended Detention	80
Sand Filters	49
Inserts	31
Infiltration Trench	18

Wet Basin Field Hours



Wet Basin

May 2000

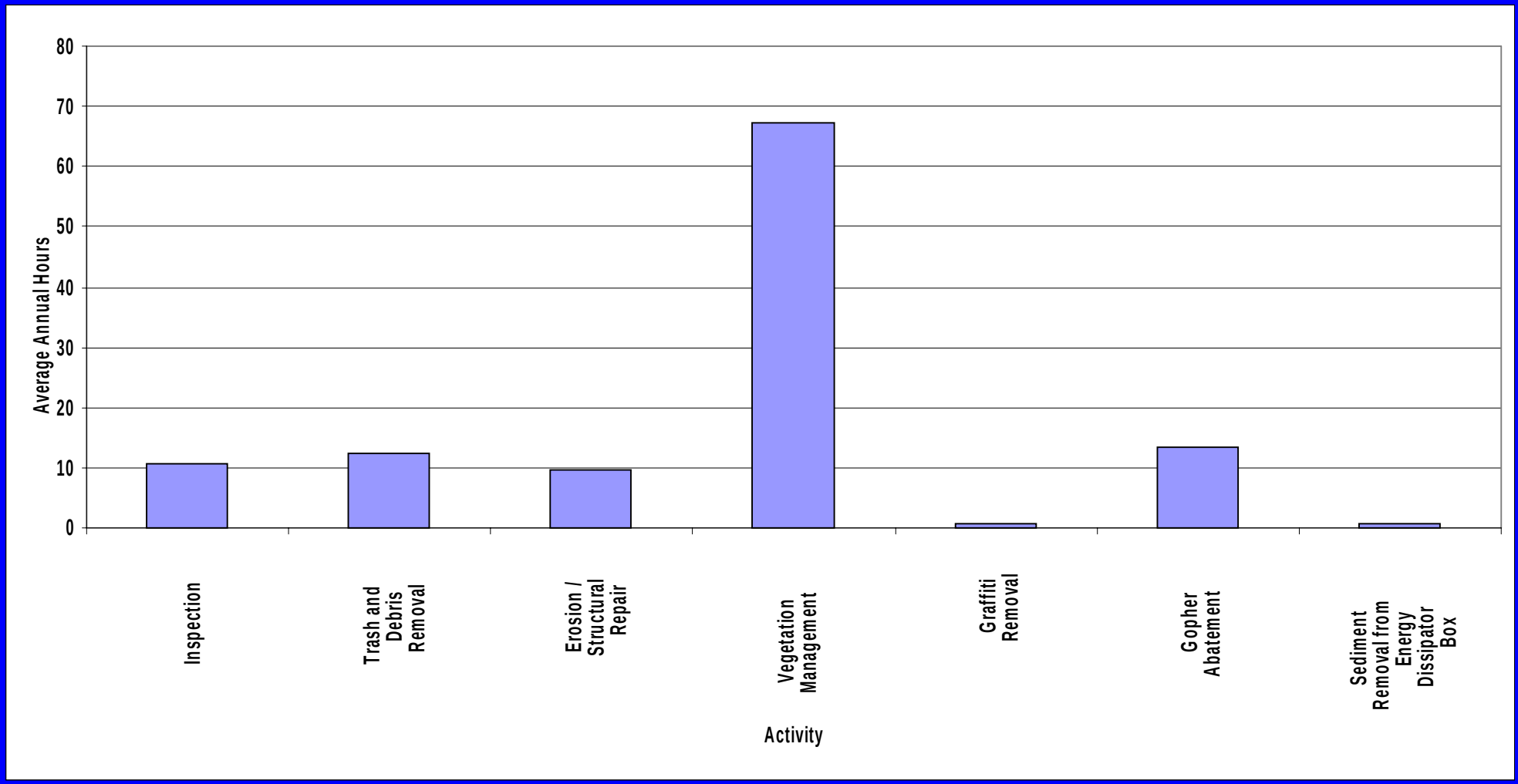
August 2000

Wet Basin

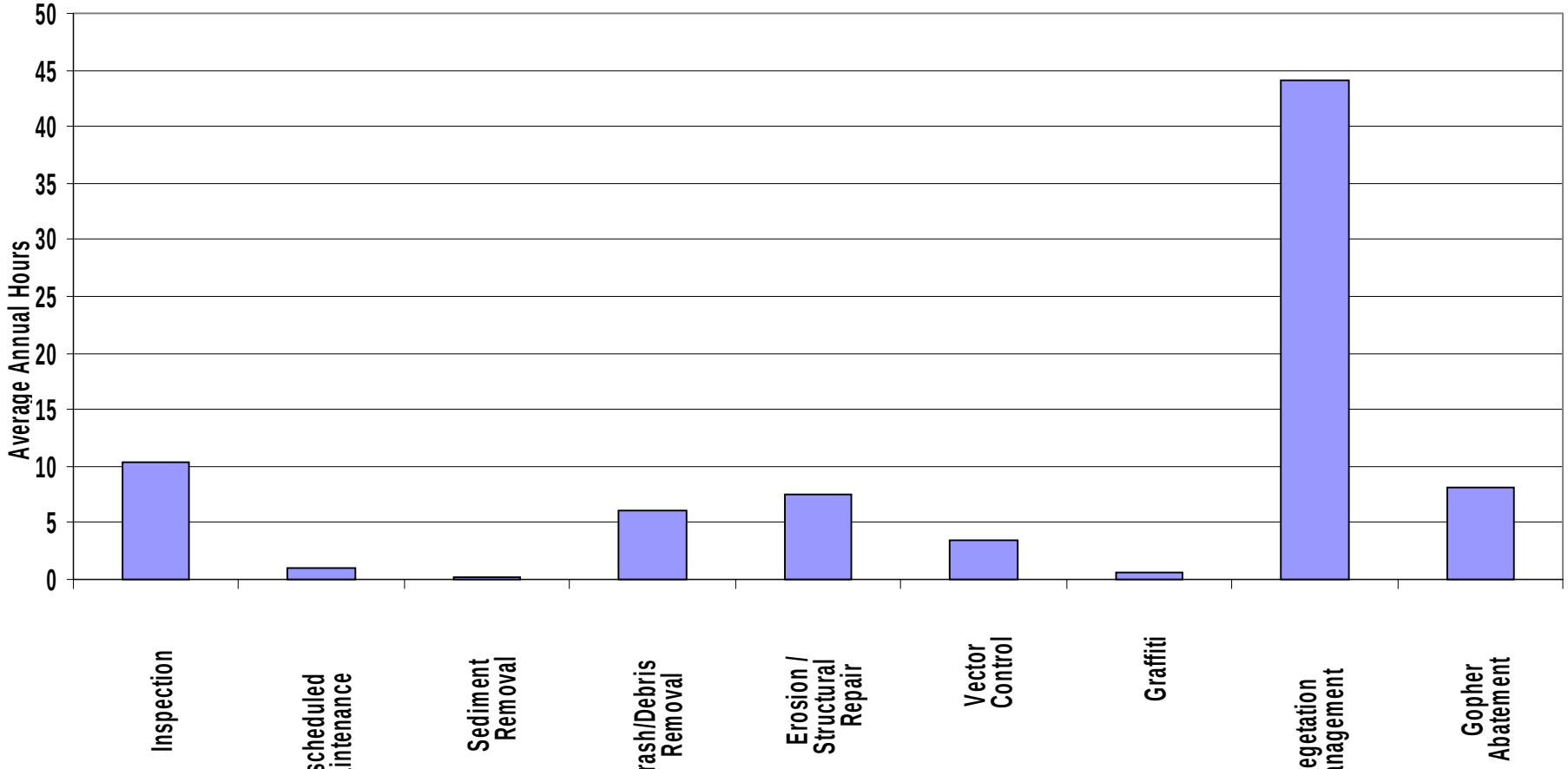
December 2000

March 2001

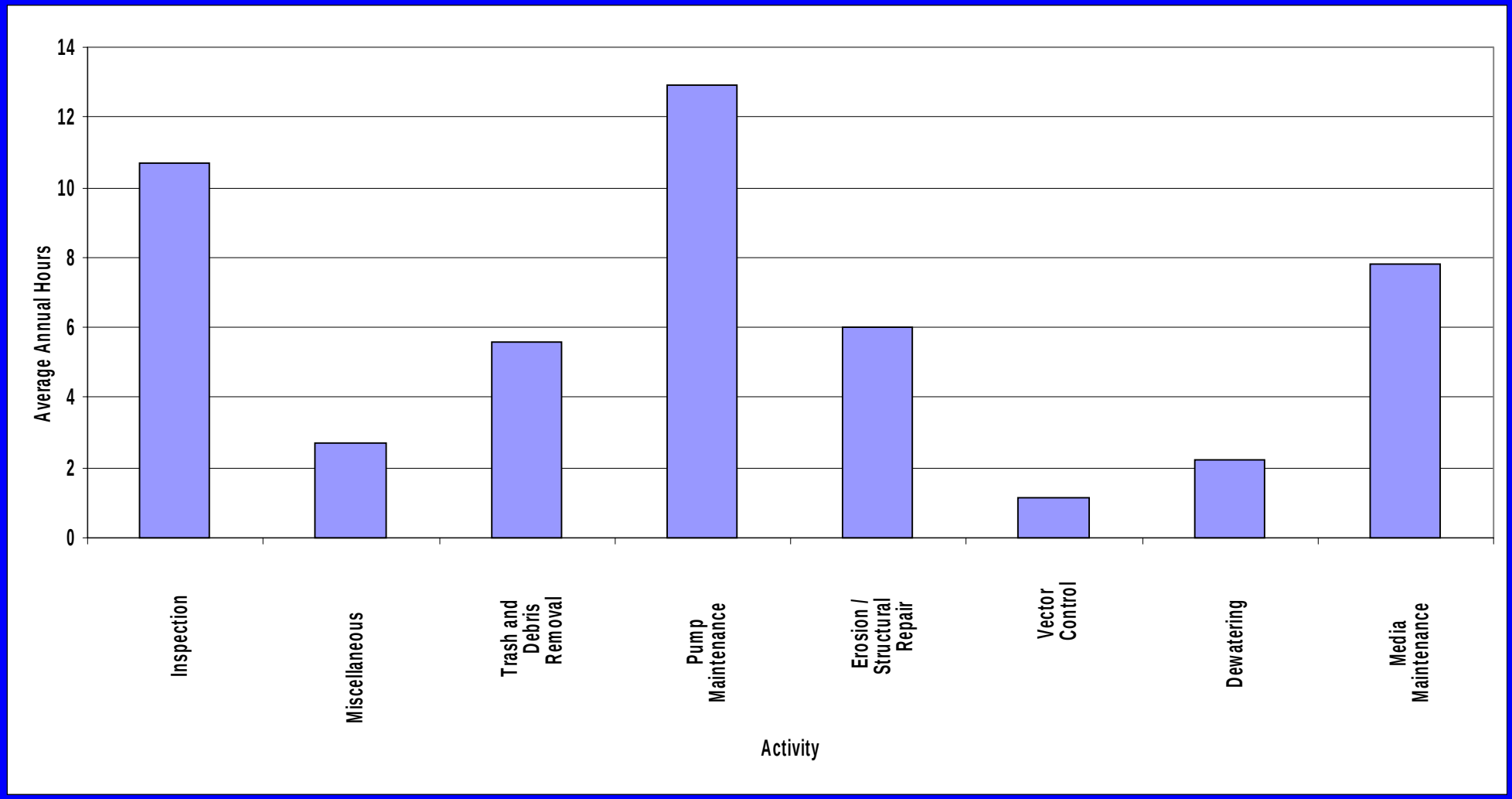
Swale Field Activities



Extended Detention Maintenance



MF Field Activities



BMP Grades

- Biofiltration Swales and Strips – A+
  - Relatively inexpensive, comparable effectiveness for many constituents, no specialized maintenance
- Extended Detention Basins – A-
  - Moderate cost, flexible siting, moderate performance, low maintenance
- Infiltration Devices – B
  - Moderate cost, highly effective, significant siting constraints and potential groundwater impacts, risky

BMP Grades

- Sand Filters – B
  - High cost, highly effective, significant head requirements, moderate maintenance
- Wet Basins – B -
  - High cost, highly effective, restrictive siting requirements, high maintenance
- MCTT – C
  - Sand filter, but more maintenance, standing water
- Inlet Inserts – D
  - Low cost, low effectiveness, timely maintenance